

THE SPATIAL DISTRIBUTION AND BONDING STATES OF CARBON ASSOCIATED WITH ALH84001 CARBONATES. G. J. Flynn¹, L. P. Keller², C. Jacobsen³, S. Wirick³, S. Bajt³, and H. N. Chapman³, 1) Dept. of Physics, SUNY-Plattsburgh, Plattsburgh, NY 12901, 2) MVA Inc., 5500-200 Oakbrook Parkway, Norcross, GA 30093, 3) Dept. of Physics, SUNY-Stony Brook, Stony Brook, NY 11794.

McKay et al. [1] have reported that carbonate globules from ALH84001 contain a variety of indicators suggesting possible ancient biological activity on Mars. One of these indicators is the detection of low abundances (>1 ppm) of polycyclic aromatic hydrocarbons (PAHs) which were "found in the highest concentration in the regions rich in carbonates." [1] In addition, they observed crystals of magnetite and Fe-S, concentrated in rims on the carbonates, of sizes and shapes consistent with a biogenic origin. However, the PAHs were detected by laser ionization mass spectrometry, using an instrument with a sampling beamspot 50 micrometers in size, comparable in size to entire carbonate globules (~50-100 micrometers), and much larger than the rims (5-10 micrometers thick) or the individual magnetite crystals (tens of nanometers in size). Determination of the spatial distribution and bonding of the carbon-bearing phase(s) may help choose between a biological origin and a high-temperature origin [2] for this material.

There are strong peaks in the x-ray absorption coefficient of carbon at energies near the carbon K-edge. The energies of these peaks are sensitive to the carbon bonding state. The C-O bond in carbonate gives rise to a strong absorption near 290 eV, while carbon in C-C, C=C, and C-H bonds has an absorption peak in the 284 to 287 eV energy range (reference Spectra in Flynn et al., Ref. 3). The Scanning Transmission X-Ray Microscope (STXM), installed on Beamline X-1A of the National Synchrotron Light Source, produces a 50 nanometer diameter monochromatic beam of x-rays, with 0.25 eV energy resolution, tunable over the range of interest. Using this instrument, x-ray absorption spectra can be measured at individual spots on the sample, identifying regions of carbon bound in molecules other than carbonate even in a carbonate rich sample, or the spatial distribution of carbon exhibiting a particular absorption peak can be mapped [3].

Fragments of two carbonate globules from ALH84001 were embedded in elemental sulfur, ultramicrotomed to a thickness of ~200 nanometers, and deposited on SiO substrates, to avoid introducing carbon absorptions from the imbedding medium or the substrate. The strong carbonate absorption at 290 eV (Figure 1) is seen throughout the carbonate region (as identified in the Transmission Electron Microscope), while some spots show the carbonate feature accompanied by absorption peaks near 285 and 286.5 eV (Figure 1), indicating the presence of a second carbon-bearing phase with C-C, C=C, or C-H. This second carbon phase may exist as discrete grains within or near the carbonate, fillings along cracks, or coatings on the carbonate grains. These STXM measurements indicate that this carbon-bearing phase is

associated with the ALH84001 carbonate on a scale of tens-of-nanometers. Mapping experiments are in progress to determine the spatial distribution of this carbon-bearing phase throughout the carbonate globule, rim, and host rock.

References:

- 1) McKay, D. S. et al., *Science*, 273, 924ff (1996).
- 2) Harvey, R. and H. P. McSweeney, *Nature*, 382, 49ff (1996).
- 3) Flynn, G. J. et al., *Lunar & Planet. Sci. XXVIII*, 365-366 (1997).

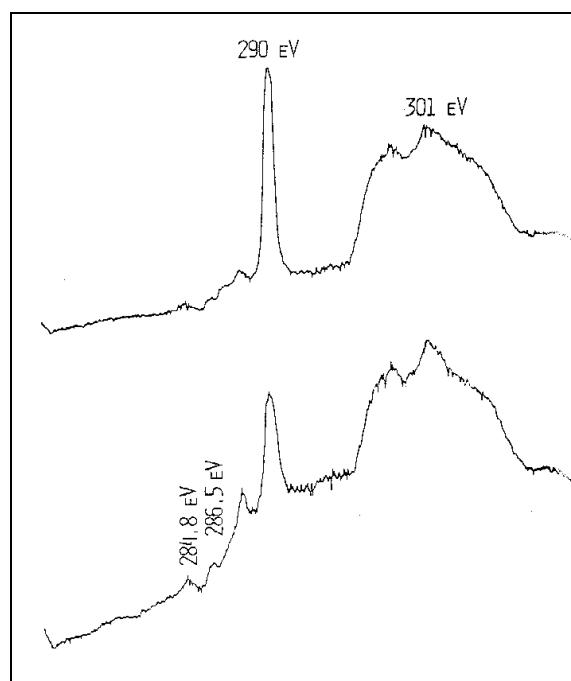


Figure 1: X-ray Near Edge Structure (XANES) spectra of two spots on a microtome section of a carbonate globule from ALH84001. Vertical axis shows x-ray absorption (in arbitrary units) versus x-ray energy (from 275 to 310 eV) on the horizontal axis. The upper spectrum is of a region dominated by carbonate (showing the 290 eV absorption of the C-O bond), while the lower spectrum is of a region exhibiting absorptions at 284.8 and 286.5 eV accompanying the carbonate absorption at 290 eV, indicating the presence of a second carbon-bearing phase associated with the carbonate.